Information for pest management professionals and pesticide applicators

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Invasive Shot Hole Borers Threatening Trees in Southern California

The Polyphagous shot hole borer (PSHB) (Fig. 1) and Kuroshio shot hole borer (KSHB) are invasive wood-boring beetles that attack dozens of tree species in Southern California, including commercial avocado groves, common landscape trees, and native species in urban and wildland environments. Both beetles spread a disease called Fusarium Dieback (FD), which is caused by pathogenic fungi. Trees that are FD-susceptible may experience branch dieback, canopy loss, and tree mortality (Fig. 2).

Insect Vector

PSHB carries three fungi: *Fusarium euwallaceae, Graphium euwallaceae* and *Paracremonium pembeum*. KSHB carries two new species of fungi: *Fusarium* sp. and *Graphium* sp. Mature females of both species are black and 0.07 to 0.1 inches (1.8–2.5 mm) long, whereas males are brown and smaller than females at 0.06 inches (1.5 mm) long. The female attacks a wide variety of host trees forming galleries (Fig. 3), where she lays her eggs. Mature siblings inbreed inside galleries and the pregnant females leave to establish new galleries in the same host or nearby hosts; most wingless males, however, remain in maternal galleries.

The tiny beetles tunnel into host trees and spread the fungi that cause FD disease. Beetle larvae within the gallery in infected trees feed on the fungus, forming a symbiotic relationship between the fungus and beetle. Fusarium Dieback stops the flow of water and nutrients in over 48 susceptible tree species, which can lead to the death of individual branches or, in severe cases, an entire tree (Fig. 2).

A. ESKALEN, UCR

Fig. 1. Adult female Polyphagous shot hole borer (Euwallaceae sp.)

A. ESKALEN, UCR

Fig. 2. Dead sycamore tree.

Symptoms

External: A host tree's visible response to disease varies among host species. Sugary exudate (also called a sugar volcano) (Fig. 4), staining (Fig. 5), gumming (Fig. 6), and frass (Fig. 7) are among symptoms that may be noticeable before the tiny beetles are found. The beetle's entry holes, which are approximately 0.03 inches (0.85 mm) in diameter, can be located beneath or near the symptoms. Advanced fungal infections will eventually lead to branch dieback.

Internal: The fungi interrupt the transport of water and nutrients in branches of affected trees, leading to wood discoloration which can vary in color from brown to black. Shaving outer layer bark with a clean knife around beetle entry holes reveals obvious wood discoloration. Cross-sections of cut branches around affected areas show the extent of infection (Fig. 8).

Wide range of hosts

These two beetles and their symbiotic fungi have a wide variety of suitable hosts. (See list on page 2). This wide host range makes landscape, native riparian, oak woodland, and mixed evergreen communities highly susceptible to invasion and mortality by PSHB/KSHB-FD.

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WHAT'S INSIDE...

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Management on Landscape Trees

If you think PSHB or KSHB is affecting trees in a landscape or area you manage, please contact your local Agricultural Commissioner's or UC Cooperative Extension before making any treatments or removing trees.

Chemical and biocontrol management strategies are currently being investigated for this pest-disease complex. Early detection of infestation and removal of the infested branches will help reduce vector populations and the spread of this pest-disease complex.

Preliminary results from ongoing pesticide experiments on sycamore trees suggest that a combination of emamectin benzoate (4%) and propiconazole (14.3%) applied as trunk injections in the wood (2-3" in the xylem), lead to a reduction in new beetle attacks over time on low-level infested trees. An earlier study also suggests that a combination of emamectin benzoate (4%) and tebuconazole (16%) applied as trunk injections in the wood were able to reduce new beetle attacks over time on infested trees.

If the infestation level on a host is moderate to heavy, we also found some level of control with trunk sprays of bifenthrin (23.4%), and a soil drench application of the systemic insecticide imidacloprid (75%). It is important to note that the chance of saving a moderate to heavily infested tree is very low. **Note: These pesticides are only registered on landscape trees.** [The mention of these pesticides does not constitute a recommendation.]

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A. ESKALEN, UCR

Fig. 3. Beetle gallery formation on box elder.

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Fig. 4. Sugar volcano symptoms on avocado.

A. ESKALEN, UCR

Fig. 5. Staining symptoms on coast live oak.

A. ESKALEN, UCR

Fig. 6. Gumming symptoms on Calpurnia aurea.

Current reproductive host list of Shot Hole Borers

1. Box elder (*Acer negundo*)*
2. Big leaf maple (*Acer macrophyllum*)*
3. Evergreen Maple (*Acer paxii*)
4. Trident maple (*Acer buergerianum*)
5. Japanese maple (*Acer palmatum*)
6. Castorbean (*Ricinus communis*)
7. California Sycamore (*Platanus racemosa*)
8. Mexican sycamore (*Platanus mexicana*)
9. Red Willow (*Salix laevigata*)*
10. Arroyo willow (*Salix lasolepis*)*
11. Avocado (*Persea americana*)
12. Mimosa (*Albizia julibrissin*)
13. English Oak (*Quercus robur*)
14. Coast live oak (*Quercus agrifolia*)*
15. London plane (*Platanus x acerifolia*)
16. Cottonwood (*Populus fremontii*)*
17. Black cottonwood (*Populus trichocarpa*)*
18. White Alder (*Alnus rhombifolia*)*
19. Titoki (*Alectryon excelsus*)
20. Engelmann Oak (*Quercus engelmannii*)*
21. Cork Oak (*Quercus suber*)
22. Valley oak (*Quercus lobata*)*
23. Coral tree (*Erythrina corallodendon*)
24. Blue palo verde (*Cercidium floridum*)*
25. Palo verde (*Parkinsonia aculeata*)*
26. Moreton Bay Chestnut (*Castanospermum australe*)
27. Brea (*Cercidium sonorae*)
28. Mesquite (*Prosopis articulata*)*
29. Weeping willow (*Salix babylonica*)
30. Chinese holly (*Ilex cornuta*)
31. Camelia (*Camellia semiserrata*)
32. Acacia (*Acacia* spp.)
33. Liquidambar (*Liquidambar styraciflua*)
34. Red Flowering Gum (*Eucalyptus ficifolia*)
35. Japanese wisteria (*Wisteria floribunda*)
36. Goodding's black willow (*Salix goddingii*)*
37. Tree of heaven (*Ailanthus altissima*)
38. Kurrajong (*Brachychiton populneus*)
39. Black mission fig (*Ficus carica*)
40. Japanese beech (*Fagus crenata*)
41. Dense logwood (*Xylosma congestum*)
42. Mule Fat (*Baccharis salicifolia*)*
43. Black Poplar (*Populus nigra*)*
44. Carrotwood (*Cupaniopsis anacardioides*)
45. California buckeye (*Aesculus californica*)*
46. Canyon Live oak (*Quercus chrysolepis*)*
47. Kentia Palm (*Howea forsteriana*)
48. King Palm (*Ptychosperma elegans*)

***Native species to California**

Invasive Shot Hole Borers ...continued from p.2

Cultural/Sanitation Practices

The removal of heavily infested reproductive hosts will help reduce vector populations and the spread of this pest-disease complex.

- Chip infested wood onsite to a size of one inch or smaller. If branches are too large to chip, solarize them under a clear tarp:
  - **July - August:** cover chips/logs with sturdy plastic for at least 6 weeks. Temperatures during these months should preferably be above 95°F (35°C).
  - **September - June:** cover chips/logs with sturdy plastic for at least 6 months.
- Have wood chips composted at a professional composting facility that has earned the U.S. Composting Council's Seal of Testing Assurance at: http://compostingcouncil.org/participants/.
- Sterilize pruning tools with either 5% household bleach, Lysol cleaning solution, or 70% ethyl alcohol to prevent the spread of the pathogens through pruning tools.
- Avoid moving infested wood and chipping material out of infested areas unless the material is covered or contained during transport.
- Transport wood or chips to a biogeneration facility (biogeneration facilities burn green waste and convert it into energy).
- Transport wood or wood chips to a landfill where it will be used as Alternative Daily Cover.

For more information, visit the UC Riverside Eskalen Lab website at eskalenlab.ucr.edu or pshb.org.

–Akif Eskalen[1] akif.eskalen@ucr.edu, Joey S. Mayorquin[1], Joseph D. Carrillo[1], Shannon C. Lynch[1], John Kabashima[2], Tim Paine[1], Richard Stouthamer[1], Frank Byrne[1] and Joseph Morse[1]. [1]Department of Plant Pathology & Microbiology and Department of Entomology, University of California, Riverside. [2]UCCE Orange County.

A. ESKALEN, UCR

Fig. 7. Frass symptoms on avocado.

A. ESKALEN, UCR

Fig. 8. Fungal colonization on a box elder tree trunk.

Phytophthora tentaculata: A New Exotic and Invasive Disease

A new plant pathogen in the genus *Phytophthora* (pronounced Fie-TOF-ther-uh) has recently been found in several California native plant nurseries and habitat restoration sites. The pathogen, *Phytophthora tentaculata*, poses a risk of disease in wildlands, gardens and landscapes that use susceptible California native and non-native plants. Once introduced in these areas, the pathogen can generate disease for years to come, potentially causing lasting environmental and economic impacts. Because both native and non-native California plants from nurseries can carry new pathogens and other pests, it is important to remember that only healthy plant material should be used for planting.

What is Phytophthora?

Phytophthoras are microscopic, fungus-like organisms called water molds that produce spores and hyphae. Many are soilborne, attack plant roots and stems, and spread by the movement of infested soil, including soil stuck to tools, containers, or shoes. The genus *Phytophthora* is large, with over 100 described species, including the sudden oak death pathogen and other destructive pathogens of agricultural, ornamental, and forest plants.

Similar to other members of the *Phytophthora* genus, *P. tentaculata* releases swimming spores that move through water and are attracted to plant root exudates. Once infected, the pathogen can cause disease in susceptible plant roots. If susceptible stems are contacted, infection can occur there following water movement or splash, and stem disease can also result from the pathogen growing into the stem from the roots. *Phytophthora tentaculata* cannot be seen with the naked eye unless grown in a laboratory. However, it usually produces visible symptoms – stem cankers and root rots – on host plants.

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Hosts, symptoms and detection

The pathogen was first described in 1993 from a nursery in Germany. In the United States, it was first found in 2012 in a nursery in Monterey County, and to date is present only in central California. Currently, seventeen plant species and two additional genera worldwide are thought to be susceptible to *P. tentaculata*, but the list may expand as we learn more. In California, eight native plant species and one additional genus have been found infected, all common in the native plant nursery trade and in wildlands. These include *Artemisia douglasiana* (mugwort), *A. dracunculus* (tarragon), *A. californica* (California sagebrush), *Salvia* species (sage), *Ceanothus cuneatus* (buck brush), *Frangula californica* (California coffeeberry), *Monardella villosa* (coyote-mint), and *Heteromeles arbutifolia* (toyon).

In California, *P. tentaculata* was first isolated from *Diplacus aurantiacus* (syn. *Mimulus aurantiacus*; orange bush monkeyflower, sticky monkeyflower) where it was observed causing aboveground symptoms (Fig. 1a) that included stunted growth, sparse and chlorotic foliage, stem collar lesions (Fig. 1b) and plant death. Root system symptoms included necrotic, sunken lesions, and few roots (Fig. 1c). Soon after, *P. tentaculata* was detected in the nursery trade in the U. S., the pathogen was recovered in central California wildlands, presumably having been released into the landscape via contaminated nursery plants used in restoration plantings. It has now been found in Alameda, Butte, Monterey, Placer, and Santa Cruz counties.

Germany, Italy, Spain, and China have reported disease from *P. tentaculata* on several plant species including *Apium graveolens* (celery), *Saussurea costus* (costus root), *Cichorium intybus* (chicory), *Chrysanthemum* species (hybrids, marguerite, and oxeye daisy), *Consolida ajacis* (rocket larkspur), *Gerbera jamesonii* (Barberton daisy), *Origanum vulgare* (oregano), *Santolina chamaecyparissus* (lavender cotton), and *Verbena* species (vervain hybrids). Many of the above species are grown in California and should be considered at risk of disease.

Prevention and Management

Prevention: By far, prevention is the best possible method for dealing with any *Phytophthora* pathogen. Consider planting from seed as *Phytophthora* in general is rarely transmitted this way. If buying container stock of any of the above plant species, find out if the nursery is following best management practices for preventing *Phytophthora* (for example: tinyurl.com/zvmjyt3). Purchase plant material that has been grown in pasteurized soil and under proper sanitation procedure. Do not use/buy plants or material that has been in the nursery for an extended time, these can become contaminated with *Phytophthora* and other pathogens.

Avoidance: Avoid buying known host-plant container stock and do not purchase plants that appear unhealthy or otherwise potentially contaminated. At more advanced stages of disease, plants may exhibit symptoms as outlined above, but nearby plants may still look healthy even though

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[IMAGES: (A) L. SIMS; (B-C) S. ROONEY-LATHAM, CD]

Figure 1. (a) Dying and dead Diplacus aurantiacus *(orange bush monkeyflower) with advanced above ground symptoms, typical of Phytophthora disease. The infected plants has chlorotic (yellowing and browning) foliage. (b) The inner stem and root crown of a diseased* D. aurantiacus *was discolored and advanced up the stem from the roots. (c)* Artemisia douglasiana *(mugwort) plant infected with P. tentaculata had a sparse root system a result of severe root rot.*

P. tentaculata ...continued from p.4

they have been contaminated through soil or water movement. If a number of plants in the nursery block show symptoms of infection, do not buy those plants or their neighbors. The host species list is a work in progress; be aware that other, unlisted species may also be susceptible.

Quarantine: If you purchase host plants (or closely related species), consider setting them aside before planting. Give the plants time (4 - 6 weeks) to develop symptoms before planting them in your yard, and be sure soil and excess water from these plants does not flow into your garden soil. If symptoms develop, dispose of the plant, soil, and container according to disposal guidelines for your area. Do not home-compost this pathogen, as it may not be killed.

Remediation: If plants are already in the ground and exhibiting symptoms such as stunted growth and/or chlorotic foliage, check the root collar and stem for necrotic sunken lesions and/or stem rots. If possible, check root systems for abnormally large numbers of dead and dying roots, few healthy new roots, and necrotic spotting on roots that are still living. If the roots appear to be infected, do not move soil from the garden bed and nearby infected plants to other parts of the garden.

Change irrigation practices to reduce the potential for *Phytophthora* growth, as outlined in the UC IPM Pest Note: *Phytophthora Root and Crown Rot in the Garden* at ipm.ucanr.edu/PMG/PESTNOTES/pn74133.html. Clean your tools and boots before working another area of your garden. You may wish to contact your local Agricultural Commissioner or UC Cooperative Extension office to see if they can offer updates or further advice.

For more information, including references to original research and related articles, see the pages covering this pathogen at www.suddenoakdeath.org/diagnosis-and-management/nursery-information/phytophthora-tentaculata/.

–Laura Sims, UC Berkeley, simslaura@berkeley.edu; Igor Lacan, UCCE San Francisco and San Mateo counties, ilacan@ucanr.edu; Steven Swain, UCCE Marin County, svswain@ucanr.edu; and Matteo Garbelotto, UC Berkeley, matteog@berkeley.edu

New law requires annual training for anyone applying pesticides at school sites

While students and teachers were enjoying summer break, an amendment to the Healthy Schools Act (HSA) went into effect on July 1st, 2016. It requires teachers, custodians, administrators, other staff or volunteers, and licensed pest management professionals applying any pesticide (this includes disinfectants and antimicrobials) at a school site to take an annual training course covering school integrated pest management (IPM). The training course must be approved by the California Department of Pesticide Regulation (DPR).

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WHAT IS IPM? Integrated Pest Management (IPM) programs focus on long-term prevention of pests or their damage through a combination of techniques including resistant plant varieties, biological control, physical or mechanical control, and modification of gardening and home maintenance practices to reduce conditions favorable for pests. Pesticides are part of IPM programs but are used only when needed. Products are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.

HSA annual training *...continued from p.5*

An online course, *Providing Integrated Pest Management Services in Schools and Child Care Settings,* developed by the UC Statewide IPM Program and the Center for Environmental Research and Children's Health (CERCH), has recently been approved by DPR to satisfy the annual training requirement of the HSA. Although this course was designed for licensed pest management professionals, anyone applying any type of pesticide in schools or child care centers will benefit from the course.

IPM is a strategy that focuses on long-term prevention of pests through a combination of techniques such as monitoring for pest presence, cleaning up food sources, sealing up cracks, and excluding pests with screens. Effective pesticides that pose the least possible hazard and that minimize harm to people, property, and the environment are used only after careful monitoring indicates they are needed.

The HSA encourages the use of IPM in schools and child care centers and gives parents and the public the ability to know when and where certain pesticides are used in these facilities. The Act was originally signed into California law in September 2000 and is located in four different California codes: education, food and agricultural, business and professions, and health and safety. The law has been amended several times. The most recent revision to the HSA was signed into law in September 2014 by Governor Jerry Brown.

Prior to July 1st, 2016, schools were already required to do the following:

- Designate an IPM coordinator at the school or district level to make sure the requirements of the HSA are met
- Create an IPM plan
- Provide annual written notification to all parents and staff of pesticide products intended for use at the school site during the year and allow the opportunity for them to be notified before certain applications
- Post warning signs where certain pesticides are applied
- Keep records of pesticide applications
- Send pesticide use reports to DPR annually

Some pesticide products are exempt from the IPM plan, notification, posting, recordkeeping, and reporting* requirements of the HSA at school sites. These are reduced-risk pesticide products, and their use is encouraged at schools if pesticides are deemed necessary. These include:

- Self-contained baits or traps
- Gels or pastes used indoors in cracks and crevices
- Antimicrobials, including sanitizers and disinfectants
- Pesticides exempt from registration, such as food grade oils

However, these products are NOT exempt from the Healthy Schools Act annual training requirement that went into effect July 1st. Anyone who uses these products—a licensed professional, school staff or child care staff—is still required to take the HSA annual training course.

To satisfy this annual training requirement, take the free UC IPM online course by visiting the UC IPM online training webpage. For more on school and child care IPM and other courses that satisfy the Healthy Schools Act training requirement, visit the DPR website.

*Licensed pest management professionals hired to apply pesticides at schools or licensed child care centers must continue to submit their regular pesticide reports of ALL registered pesticides to DPR annually and to the county monthly.

–Cheryl Reynolds, UC Statewide IPM Program, creynolds@ucanr.edu

University of California
Division of Agriculture and Natural Resources
Statewide IPM Program
2801 Second Street
Davis, CA 95618-7774
E-mail: ucipm@ucanr.edu
Online: www.ipm.ucanr.edu/greenbulletin
Editor: K. Windbiel-Rojas
Production: F. Rosa

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For more information about managing pests, contact your University of California Cooperative Extension office listed under the county government pages of your phone book, or visit the UC IPM Web site at www.ipm.ucanr.edu.